Classical Biocontrol: Panacea or Pandora's Box[1]

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Like Gaul, biological control (or biocontrol) can be divided into 3 parts: cultural practices which enhance beneficial species already present; mass rearing of selected beneficial species for release against a pest; and, what has been termed classical biocontrol, the discovery, importation and release of a foreign species with the expectation that it will control a pest population. My comments will primarily concern classical biocontrol and stem from my experience as curator of the Hawaiian insect collection at the Bishop Museum, my research on native Hawaiian ecosystems, and my concern for conservation of native and endangered species. I thank W.C. Gagné for many helpful discussions during the preparation of this paper.

Classical biological control blossomed in Hawaii in the late 19th and early 20th century, when a great many animals were indiscriminantly introduced, and the method has been used with some impressive economic successes both in Hawaii and elsewhere ever since. Enthusiasm for the method has resurged during the last 2 decades, after the fall from favor of chemical pest control. I share some of the enthusiasm towards the prospects of biocontrol, and it is not my position here to belittle the impressive successes being made in the control of economic pests. However, I am alarmed by several recent treatments and reviews on classical biocontrol that have touted the method as being without environmental risks. For example, DeBach (1974) stated that ". . . no adverse effects on the ecosystem occur from biological control." Doutt (1972) called the method "environmentally safe". Simmonds and Bennet (1977) writing on classical biocontrol, wrote, "In the past it has been made abundantly clear that research in this sphere results in prodigious economic benefits — without *any* environmental hazards — . . ." Harris (1977) considered it a "safe method". Furthermore, these authors and others have outlined the limitations and considerations of biocontrol but, in general, have not included even the slightest mention that there may be some harmful side effects, although some of the environmental risks inherent in biocontrol of weeds are recognized (Andres and Goeden 1971). Even though Huffacker et al. (1977) indicated that there may be some risks involved with the biocontrol of weeds, they implied that there were no such risks with the introduction of insect enemies, and, in a comprehensive list of 8 "Attributes of an Effective Natural Enemy", mention of environmental risks was conspicuously absent.

Not only are such statements and ommissions patently false, they represent a dangerous attitude. In fact the current press coverage of classical biocontrol as a non-disruptive, non-pollutive method — a panacea as it were — is analogous to and even reminds one of the euphoria about pesticides expressed in the 1940's and 1950's. This is dangerously misleading because it encourages the interested and well-meaning public to import on his own virtually any organism he feels would be useful.

Furthermore, virtually all authors have analyzed the successes and failures of biocontrol introductions solely on the basis of whether the target pest was controlled (see Stehr 1974). Why are researchers in this field so loathe to analyze the environmental risks involved with introductions of exotic species? The lack of this

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analysis is unfortunate because not only does the environment lose, and the advance of biocontrol as a science stagnate, but also, as such environmental failures mount, the public will withdraw its support, and applied ecology will suffer another black eye, as it has with chemical control. Many animals broaden their diets when introduced into new lands, potentially becoming detrimental instead of helpful (Carson & Ohta 1981). Experience with classical biocontrol introductions to date have involved significant negative impacts on agriculture, native ecosystems, and human health.

I do not have time here to give a full review of biocontrol's successes and failures nor do I think you would prefer to sit through such a presentation. Besides, even for Hawaii, no records exist for a great many of the species introduced (Swezey 1931), and little has been published on the environmental impacts of biocontrol. However, I would like to express some of my concerns relating to biological pollution. Biological pollution is the establishment in the wild of foreign or non-native organisms. Let me preface these remarks by stressing that biocontrol is not the only scapegoat of biological pollution. In fact many introductions, both inadvertant and purposeful, for food and ornament have been at least as destructive, perhaps more so, than biocontrol introductions. Some better known examples in Hawaii are the ants and feral pigs, goats, sheep, and cattle, and the weeds, lantana, Coster's curse, and banana poka. However, experience has shown that there are serious risks to the natural environment involved when foreign organisms are purposefully established in a new land. Zimmerman (1958) lamented the loss of Hawaii's moth fauna thusly: "The importation of parasites to control various moths of economic importance, together with the accidental importation of other parasites, has resulted in wholesale slaughter and near or complete extermination of countless species. It is now impossible to see the Hawaiian Lepidoptera in the natural proliferation of species and individuals of Perkin's day. Many are forever lost."

Zimmerman (1948) also believed that the reduction of native caterpillars led to the rarity and perhaps extinction of native predators, especially *Odynerus* wasps. Banko (1978), and Gagné (1981) have made a strong case that this decline of native arthropods, particularly Lepidoptera, was one of the main factors in the decline and extinction of Hawaii's insectivorous birds. Meager caterpillar populations during the critical breeding period of forest birds could drastically reduce reproductive success. The old one-two punch of loss of habitat and food, together with the increase of exotic predators and diseases coupled with the small precinctive island area, doomed many native birds to extinction. It may be too late to single out one cause in hindsight, but equally it would be a worse mistake, for the survivors, to exonerate any one factor simply because we do not know. Unfortunately, there is now documentation that the exotic predatory snail, *Euglandina rosea* (Férussac) which was introduced in 1955 for giant African snail (*Achatina fulica* Bowdich) control, has extirpated populations of the beautiful endemic Oahu tree snail *Achatinella mustelina* Mighels (Hadfield and Mountain 1981). This documentation confirms the circumstantial evidence incriminating the predatory snail since the marked decline and possible extinction of many species of endemic snails corresponded to the spread of the predatory snail (Christensen, pers. commun.).

In a recent review of insect conservation Pyle et al. (1981) believed that exotic organisms, both inadvertantly and purposefully introduced, were a more serious threat to beneficial insects than were insecticides, and in fact they found no authenticated case of an insect extinction as a direct result of insecticide application, except possibly some symbionts of birds of prey. This seems quite surprising since pesticides, whose chief target is insects, have been the scapegoat of the modern environmental movement. This lack may only reflect the absence of data on the effects of pesticides on nontarget arthropods in general. In fact there now may be a well documented case, since the Colorado Department of Agriculture inadvertantly sprayed the last known surviving colony of the Colorado hawk moth, *Euproserpinus weisti* Sperry, this past summer during an ecological study to determine its requirements for possible listing as an endangered species (Pyle, pers. commun.). Closer to home in Hawaii, there are many Society members who fear that the proposed tri-fly eradication program, if instituted, may be one of the most serious threats ever to impact the native Hawaiian arthropods.

But in fact, the evidence indicates that biocontrol has had a greater environmental impact by causing more species extinctions than has chemical control (e.g., Honegger 1981). Yet many authors have condemned chemical control while espousing classical biocontrol as environmentally safe. A comparison of the environmental considerations of chemical and biological pest control reveals several interrelated areas of concern: (1) reversibility, (2) specificity, (3) area covered, (4) research, (5) economics, and (6) biosystematics.

(1) Reversibility:

With some few exceptions the impacts of chemical pesticides are reversible, that is, when environmental damage is detected it is possible to stop the application or even switch chemicals and the ecosystems recover. On the other hand, once a foreign biocontrol agent becomes well established, history has shown that it is nearly impossible to eradicate it, and therefore biocontrol must be considered essentially irreversible. In some cases when one biocontrol agent went awry or became 'too successful' other biocontrol agents were introduced to control the first animal, e.g., *Orthezia* control (Perkins and Swezey 1924), — the only arena where 2 wrongs supposedly make a right.

DeBach (1974) argued that the permanence of biocontrol is an advantage. I am not so sure. Given economic realities it is doubtful that the same land use will be followed for decades, let alone centuries.

Today's beneficial animal could be tomorrow's pest. A few examples: the mongoose and hornfly control on pasture land (Tomich 1969); conversion of pasture land to teak culture where lantana has been controlled; and certain aquaculture ventures after either mosquito fish or grass carp have been introduced (Rao et al. 1971; Davis 1980).

(2) Specificity:

Pesticides are often broad spectrum biocides, and the economics of pesticide development and marketing dictate that this trend will continue. This clearly is a great disadvantage for environmental considerations, especially when coupled with persistence or widespread use. Biocontrol has similar considerations. Even though experience has shown that the most successful cases of biological control have utilized highly host specific species (DeBach, 1974; Huffacker et al. 1971), biocontrol enthusiasts are still encouraging the introduction of large numbers of species, including those with broad host ranges. Furthermore, it is often the generalist that has caused the major environmental problems. Far too many introduced animals have switched hosts and attack either innocuous native species or even other beneficial biocontrol agents (Gagné 1972; Zimmerman 1958). So many generalist parasitic Hymenoptera have been introduced to Hawaii that it is now difficult to affect biocontrol of weeds by lepidopterous herbivores; witness *Clidemia*, blackberry and lantana control attempts. This background pollution caused by previous shotgun biocontrol introductions must be recognized and new agents selected accordingly. Biocontrol agents have often been called natural enemies; yet since many were not native to the homeland of the pest, they are in reality *un*natural enemies.

(3) Area Covered:

The costs of pesticide applications has meant that their use has been primarily on economic crops and pests. Some experimental government forest and range pest control is an exception. Even though there have been serious problems with drift, water pollution, and biological magnification of pesticides in the environment, in general, pesticide applications stay put. Furthermore, there is a body of knowledge concerning physical parameters to measure in order to determine the amount of drift, biological magnification, and transport out of the sprayed area. In contrast, there are no overt physical barriers to prevent biocontrol agents from walking or flying out of the area where released and entering neighboring habitats, including non-croplands, and there is no body of knowledge from which one could predict the impact of a specific introduction (Debach 1974). Of greatest concern in this regard is the fact that most biocontrol workers apparently fail to realize that there is even a problem.

(4) Research of Efficacy and Impacts:

The problems associated with pesticide control, particularly the high costs, necessitated workers to gather information on the effects of the chemicals in the field even prior to the environmental movement of the 1960's, so that some methods were available when the need arose to monitor the impacts on non-target organisms. Not so with biocontrol. Once the target pest appears adequately controlled researchers have turned their attention to other pests. Furthermore, if control breaks down the agriculturalists have traditionally turned to trying new introductions with little regard for what happened to the earlier attempts. Unfortunately there have been extremely limited funds for research on the efficacy and impacts of biocontrol attempts. No pesticide company would be allowed to market a product without such studies. Many biocontrol success stories remind me of the story of the malihini who kept snapping his fingers while visiting native forests on Molokai. When pressed for an explanation he confessed it was to keep any big snakes away. And he was sure that it worked, since he saw none! The ecological requirements of candidate species in their native habitats should be known in order to assess their potential efficacy and risks before introduction in the new land. Fortunately, rigorous controlled experiments to determine the efficacy of biocontrol are now being advocated (DeBach 1974), and the Hawaii State Department of Agriculture has begun including vulnerable native arthropods in their testing protocol for candidate species.

(5) Economics:

As noted above, economic considerations have dictated the strategies used in pest control. Is the control really necessary? The chemical industry is well known for its scare stories and advertising schemes which encourage farmers and the public to apply insecticides for 'insurance' where they are not really needed. Classical biocontrol, being relatively inexpensive, has attempted to control nuisance problems which should properly have been solved by cultural practices, for example the pineapple souring beetle, or even left to run their course, for example, the current whitefly mania.

By whose definition is an introduction useful? A public survey would probably show that some people would be in favor of almost *any* introduction. History confirms this, for over the years of Western contact people have purposefully imported into Hawaii and released, bats (in hindsight possibly with rabies), lizards, toads, pestiferous birds, weeds, and a whole host of vermin, all under the guise of usefulness.

Fortunately, not all of these established, but some did. The specific wasp pollinators necessary for reproduction in several species of fig trees were purposefully introduced under the guise of biocontrol (Swezey 1931) yet some of these tree species are known to be weeds.

(6) Biosystematics:

Insect control has advanced concurrently with the improvement of our understanding of the systematics of the pests and their relatives. There are many examples of control failures which were due primarily to the improper identification of the pest, and in general one could claim that the better a pest is known the more likely a successful control method can be found. However, as stressed by DeBach (1974) biocontrol also requires a good foundation and understanding of the systematics of the candidate control agents as well as the pest. Thus biocontrol requires much more systematics research to be effective. In this regard, well prepared, labelled, and preserved voucher specimens of all species released into the wild are extremely important (Stehr 1974). Until we get a handle on the systematics and ecology of the dominant organisms living in agro-ecosystems our control procedures will be relegated to coping with crises as they arise rather than management of pest populations.

By now it should be obvious to applied entomologists that there can be no panacea in pest control. Given the high reproductive potential and the genetic plasticity of insects, the development of resistance to artificial population controls is a biological phenomonon. Some pest species have evolved ways to cope with any single control method applied to drastically reduce their populations, whether the control is chemical, biological, cultural, or genetic. Human agro-ecosystems are young and maintained for high harvestable productivity. The large acreages planted to one or a few crops amounts to millions of succulent, attractive bait stations. Eventually one or more species will break through our defenses and become a pest. In the long term only an integrated system utilizing the full range of control methods and based on firm knowledge of ecology will maximize returns without placing a stress on earth's life support systems (Anon. 1980).

Classical biocontrol has been shown to be largely irreversible, and, therefore, should have more limited application. The hit and miss shotgun approach of multiple species introductions for biocontrol espoused by Huffaker et al. (1971) must end. This does not mean that biocontrol has little promise. Actually, biocontrol has tremendous promise, but the persons who attempt to introduce animals and plants beyond their normal range undertake a grave responsibility. Society must discourage exotic introductions in principle. Before introductions can be regarded as safe it must be proved conclusively that the new organisms will not harm the native flora and fauna, human health, or local industry.

The first priority in control should be understanding the ecology of the pest in relation to the environment and economic loss, with a view of separating aesthetic problems and those with cultural solutions from those with more genuine economic or basic biological problems. For example, in Hawaii many weeds may be reduced by modifying grazing or disturbance pressures, particularly by feral mammals.

A cultural practice that would significantly reduce our pest problems and be of great benefit to the environment would be to convince the chemical and advertising industries to reverse their stand that the only good bug is a dead one! If we could educate Americans to appreciate the aesthetics and interest of insects and other so-called "creepy-crawlies" we could solve the majority of our pest problems. It has always bothered me that urban and suburban areas in the U.S. are such biological deserts, populated by hoards of a few scavenging species which are able to cope with the pesticides, pollution, and people. So what if our ornamentals have a few tattered leaves? It makes them much more interesting to look at!

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